Chemistry Quiz
Acids, Bases, and Acid-Base Equilibrium
Instructor's Version B

Answer Sheet

1.	A
2.	E
3.	C
4.	A
5.	B
6.	D
7.	E
8.	A
9.	A
10.	A

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Free-Response Questions
Time Limit: You have 30 minutes to complete this section.
Scoring: 60 points total; Question 1 is worth 40 points and Question 2 is worth 20 points; points for each section are indicated within the questions.
Calculator Use: You may use a calculator on both questions.

1. A 0.150 M solution of nitrous acid (HNO_2) is made. $K_a = 4.5 \times 10^{-4}$

A. Show the equilibrium which occurs when this acid is dissolved in water. (5 points)

Answer: $HNO_2 + H_2O \Leftrightarrow NO_2^- + H_3O^+$

B. What is the pH of the solution? Show all work clearly. (5 points)

Answer:

	HNO_2	+ H_2O ⇔	NO_2^-	+ H_3O^+
[initial]	0.150		0	0
[change]	- x		+x	+x
[equil]	0.150 – x		x	x

Since K_a is small, $0.150 - x \sim 0.150$, so: $4.5 \times 10^{-4} \sim x^2 / 0.150$
$x = [H_3O^+] = 0.008216$ (not rounding until the end)

pH = - log (0.008216) = 2.09 (the decimal places in pH = the number of significant digits in the concentration).

C. 100.0 mL of the solution is titrated against 0.150 M NaOH. What is the pH at the equivalence point? Show ALL work clearly. (20 points)

Answer: At the equivalence point, a stoichiometric proportion of NaOH has been added to react with all of the HNO_2:

$$NaOH + HNO_2 \rightarrow NaNO_2 + H_2O$$

The $NaNO_2$ is dissociated into Na^+ and NO_2^-. The NO_2^- is in equilibrium with the water:

$$NO_2^- + H_2O \Leftrightarrow HNO_2 + OH^-$$

[initial]	0.0150 mol or 0.075 Molar		0	0
[change]	-x	+x	+x	
[equil]	$(0.075 - x) \sim 0.075$		x	x

$K_b (NO_2^-) = K_w / K_a = 2.22 \times 10^{-11}$ and $K_b \sim x^2 / 0.075$

So $x \sim 1.3 \times 10^{-6}$ therefore pOH = 5.89 and pH = 8.11

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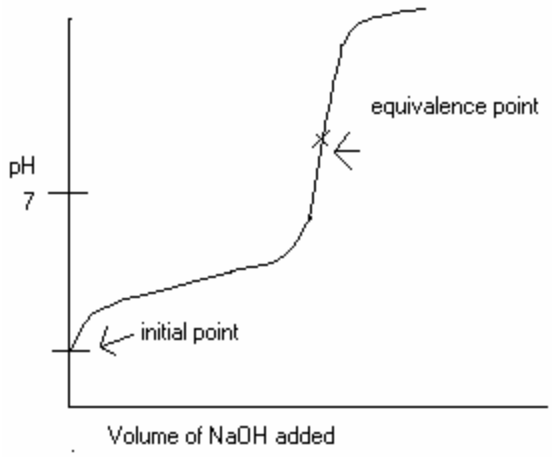
D. Sketch the titration curve, accurately indicating pH=7, the starting point, and the equivalence point. (5 points)



E. What is true about the pH and pKa, and the [acid] and [conjugate base] at the half-equivalence point? (5 points)

At the equivalence point the pH = pK_a and the [acid] = [conjugate base]

2. Some $NaHSO_3$ is dissolved in water.

A. Show the equilibrium equation which results. (5 points)

HSO3- + H2O <=> SO3 2- + H3O+

B. Which acid or base would you choose to make a buffer with the salt in A and why? (5 points)

H_2SO_3	**$K_a = 1.3 \times 10^{-2}$**
HSO_3^-	**$K_a = 6.3 \times 10^{-8}$**
SO_3^{2-}	**$K_b = 1.6 \times 10^{-7}$**

The conjugate base is SO3 2-, so that is the one that should be chosen to make a buffer.

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C. What is the pH range of this buffer? Show work clearly. (5 points)

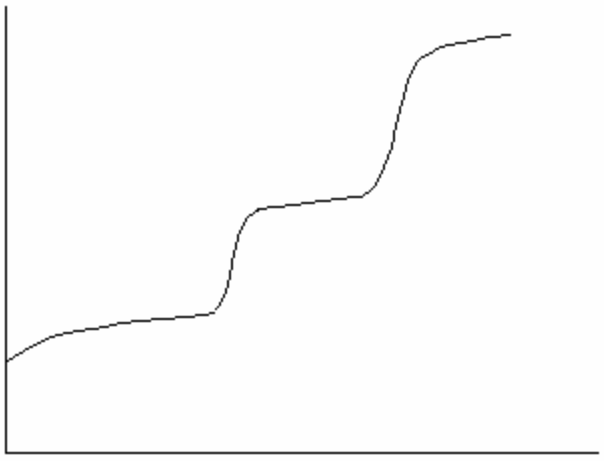
Answer: The pH range is +/- 1 around the pKa, so students must first determine the Ka of SO3 2- this way:

Ka = Kw/Kb = 1.0x10^-14 / 1.6x10^-7 = 6.3x10^-8

Then they take the negative log of that #: -log(6.3x10^-8) = 7.20

So the buffer range is 6.20 - 8.20

D. What is the general shape of a titration curve between H_2SO_3 and NaOH? (5 points)



The diagram should be graded to show two equivalence points and a general shape such as that shown above.

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